{SEQ CHAPTER \h \r 1]UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460
April 6, 2006

[SEQ CHAPTER \h \r 1] OFFICE OF
PREVENTION, PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Preliminary Impact Analysis for Aldicarb on Major Citrus Crops (DP 299884)

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Peer Review Panel: March 15, 2006

SUMMARY

Aldicarb is a systemic carbamate pesticide used to manage insects and nematodes on citrus. As part of the risk-benefit analysis for reregistration, BEAD conducted an analysis of possible alternatives to aldicarb used on the major citrus crops, oranges and grapefruit, in Florida and Texas. There appear to be several alternatives to aldicarb for control of mites, but there appears to be no feasible alternative to aldicarb for nematode control. Estimated yield losses in Florida

without aldicarb are 5 to 10 percent, which corresponds to a loss of about $97 to $193 per acre to orange growers and $109 to $218 per acre to Florida grapefruit growers. Statewide, the aggregate impact of a 5 to 10 percent yield loss corresponds to an annual loss of about $4.6 to 9.3 million for oranges and grapefruit combined. Aldicarb is not registered for use on citrus in California. There appear to be alternatives to aldicarb for mite control in Texas citrus.

BACKGROUND

Aldicarb (Temik® 15G) is a carbamate pesticide used to manage several insects, mites, and nematodes on citrus. Aldicarb poses dietary risks, in addition to acute risks to birds, mammals, and aquatic organisms. There are also chronic risks to invertebrates (freshwater and estuarine/marine) and freshwater fish. BEAD conducted an alternatives assessment as part of the risk management process.

BIOLOGICAL ANALYSIS

Crop Production

Florida is first in citrus production across all citrus crops, California is second, and Texas is third (Crop Profile for Citrus in California, 2003). Florida is also first in production of the major citrus crops, oranges and grapefruit, and California is second. Table 1 shows the citrus acres grown and aldicarb usage on these two crops.

Table 1. Citrus Acreage and Aldicarb Usage in Major Producing States[1]

State	Grapefruit Acreage[2]	Estimated Pounds AI Applied Grapefruit	Grapefruit Percent Crop Treated (%)	Orange Acreage[2]	Estimated Pounds AI Applied Orange	Orange Percent Crop Treated (%)
Florida	71,000	38,000	14	541,800	118,000	7
California[3]	12,500	NA	NA	176,000	NA	NA
Texas	18,500	43,000	49	8,800	0	0
US Total	128,119	100,000	10	926,815	400,000	5

Sources: USDA NASS and EPA Proprietary Data (1998-2002).

[1] Usage of aldicarb as a nematicide may not be reflected by these data sources because these data are not available to BEAD.

[2] Bearing acres are reported at the state-level from USDA NASS Citrus Fruits 2005 Summary

[3] Aldicarb is not registered for use on citrus in California.

Citrus production in Florida is mainly in the central ridge and southern parts of the state. Approximately 90 to 95 percent of Florida oranges are processed for juice (Crop Profiles for Citrus Major) Orange/Grapefruit in Florida, 2001). Although more than half of Florida grapefruit are processed, most of the grapefruit crop produced is initially intended for the fresh market.

Texas citrus is mainly produced in Hidalgo, Cameron and Willacy counties of the Rio Grande Valley. Most of the state's citrus acreage grows grapefruit for fresh market.

USE AND USAGE OF ALDICARB ON CITRUS

Aldicarb is a systemic and contact carbamate insecticide and nematicide. TEMIK® brand 15G Aldicarb is a restricted use pesticide which is used in some citrus-producing states primarily to control mites and nematodes. In addition to these pests, aldicarb is registered to control aphids, and whiteflies. Aldicarb is applied just before or during spring flush of foliage growth in bands along tree rows. This granular formulation is labeled for soil application and may be applied only once per year. Granules must be immediately covered with at least two inches of soil.

In Florida, aldicarb can only be applied between January 1 and April 30 and can never be applied within 300 feet of drinking water wells. Aldicarb use in Florida is further restricted based on soil permeability.

Aldicarb is not registered for use on citrus in California. There are no use restrictions specific to Texas. The Section 3 registration excludes aldicarb use on citrus to control nematodes in Florida, but this use is allowed under a 24(c) registration. Additionally, aldicarb is now recommended by the registrant for use on the Asian citrus psyllid in Florida and Texas.

Aldicarb use in citrus production is significant in Florida and Texas in terms of pounds applied and percent crop treated, respectively (Table 1). Nationally, aldicarb use on grapefruit has decreased over the last five years and slightly decreased on oranges. There has been no reported use on oranges in Texas since 1998.

IMPORTANT CITRUS PESTS CONTROLLED BY ALDICARB

Mites

Mites are the primary citrus pest in both Florida and Texas.

According to the Crop Profile for Citrus in Florida (2001), the citrus rust mite is the primary insect pest in Florida. Rust mites feed on fruit, stems and foliage. Fruit damage caused by rust mites is mainly a reduction in fruit grade and size, increased water loss, fruit drop, and reduced juice quality. Leaf injury includes discoloration of foliage. Citrus rust mites are generally worse in warm, humid weather. In general, miticides are used three to four times per year on citrus for fresh market, while a maximum of one treatment is applied to citrus for processing.

Mites are the most economically important pest in Texas citrus production (Cartwright and Browning). Important mites are the citrus rust mite and spider mites, which include Texas citrus mite and citrus red mite. Unlike the citrus rust mite, Texas citrus and citrus red mites thrive in hot, dry conditions. In Texas, the citrus red mite has not caused reductions in fruit quality although it has caused leaf drop. Grapefruit are more vulnerable than oranges to damage by citrus rust mites and citrus red mites (Cartwright and Browning).

Asian Citrus Psyllid

The Asian citrus psyllid, *Diaphorina citri*, is a relatively new pest to Florida. Although aldicarb is not the primary method of control, this insect is considered an important pest because it vectors citrus greening disease, which was found in Florida in late 2005 (Hall, 2006). Citrus greening disease causes stunted trees with leaf and fruit drop. Fruit can be hard, small and discolored (Grafton-Cardwell, 2005). Although the Asian citrus psyllid was found in Texas in 2001, citrus greening disease does not appear to be in Texas.

Nematodes

The main nematodes of concern in Florida are the citrus nematode and burrowing nematode (Crop Profile for Citrus (Major) Orange/Grapefruit in Florida, 2001). Other nematodes with limited economic importance in Florida are the sting nematode and lesion nematode (Duncan, et al., 2006). Nematodes generally do not kill citrus trees but may inhibit growth and fruit production. Although the citrus nematode is found in Texas citrus orchards, only 2 percent of the crop is treated with aldicarb (A Texas Citrus Pest Management Strategy, 2003). Aldicarb must be applied multiple times over the life of the orchard, and it only provides temporary nematode suppression. Aldicarb is registered to control the citrus nematode. It does not effectively control the burrowing nematode as aldicarb only remains in the shallow part of the root zone (Duncan et al., 2006).

ALTERNATIVES FOR ALDICARB USE ON CITRUS

There are many pesticides registered to control mites and psyllids on citrus in both Florida and Texas (Table 2). Chemical controls are used to control mites mainly on citrus intended for the fresh market. Since fruit growth is affected by greater than 50 to 75 percent injury, processed fruit generally required less chemical control for mites (Childers, 2006).

Table 2. Important Citrus Pests Controlled by Aldicarb and Potential Alternatives

State	Pest	Potential Alternatives and their Relative Efficacy[1] if Available	Comments
Florida	Citrus Rust Mite	abamectin, dicofol, diflubenzuron, fenbutatin-oxide (E), oxamyl, petroleum oil, propargite, spirodiclofen (E), sulfur	Dicofol, fenbutatin-oxide, and spirodiclofen are recommended for use in the spring, which is when aldicarb may be used in Florida.
	Asian Citrus Psyllid	chlorpyrifos, fenpropathrin, imidacloprid	This pest vectors citrus greening disease. It is unlikely it can be completely controlled by chemicals, including aldicarb.

State	Pest	Potential Alternatives and their Relative Efficacy[1] if Available	Comments
Florida	Citrus Nematode	Fenamiphos*	Repeated use of fenamiphos results in lowered efficacy due to development of resistance. *Registration cancelled, effective 2007.
Texas	Citrus Rust Mite	Abamectin (E), diflubenzuron (E), fenpropathrin (G), petroleum oil (G), formetanate hydrochloride (E), propargite (G-F), pyridaben (E), dicofol (E), chlorpyrifos (G), sulfur (G), fenbutatin-oxide (E), oxamyl (E)	
	Spider Mites	Spider Mites - all Abamectin (G), dicofol (E), fenbutatin-oxide (E), fenpropathrin (E), pyridaben (E) Texas Citrus Mites - only Propargite (G), Citrus Red Mite - only Propargite (E), petroleum oil (E)	

[1] *Efficacy rating symbols: E=Excellent (80-100% control), G=Good (60-80% control), F=Fair (<60% control), based on A Texas Citrus Pest Management Strategy (2002) and TAMU Insecticide and Miticide Guide. Additional sources include: University of Florida's Institute for Food and Agricultural Science Extension (IFAS), Crop Profile for Citrus in Florida, Florida Entomological Society Annual Meeting2003.*

Since miticides are effective at different times throughout the season, Florida has developed the following recommendations (Childers et al., 2006). Petroleum oil should be applied post bloom in summer or fall, but cannot be used when temperatures are higher than 94 degrees. Petroleum oil provides good control, is found to have fungicidal properties, and does not harm beneficial organisms. Oil is commonly mixed with other chemicals, such as abamectin, to improve their performance. For example, abamectin plus oil provides broad spectrum insect and mite control. Sulfur provides suppression of citrus rust mites. Sulfur has no pre-harvest interval and can, therefore, be applied late in the season, but may have harmful effects on beneficial arthropods. The use of propargite is recommended in the fall. Propargite should not be applied to immature leaves or fruit. The pyridaben label states that due to mite resistance it must be alternated with other miticides. The Florida PMSP recommends that all miticides, except petroleum oil, only be used once a year to prevent insect resistance from developing (Childers et al., 2006).

Many of the recommended pesticides have limited use or some use restrictions, especially in Florida. Use of pesticides, including aldicarb, in Florida may be restricted based on distance to water bodies, ground water and soil types. In Florida, aldicarb can only be applied from January

1 through April 30. Other miticides that are recommended for early spring include dicofol, fenbutatin-oxide, and spirodiclofen. Multiple uses of dicofol have resulted in mite resistance. Fenbutatin-oxide is considered an excellent citrus miticide and easy on beneficials. It is recommended for use in spring or fall. Spirodiclofen is also considered an excellent control of citrus rust mites, but is best for preventative or early mite control; it does not control adult males (Childers et al., 2006; Bell et al., 2003).

There are more potential alternatives for aldicarb in Texas than in Florida. Abamectin, diflubenzuron, pyridaben, formetanate hydrochloride, dicofol, fenbutatin-oxide, oxamyl are considered to have good to excellent control of citrus rust mites (Browning and Cartwright, 2006). Dicofol, fenbutatin-oxide, fenpropathrin, pyridaben, propargite, and petroleum oil are recommended as good to excellent controls of spider mites (Browning and Cartwright, 2006). Oxamyl is a systemic pesticide that provides some residual control although aldicarb has longer residual control.

It is unlikely that the Asian citrus psyllid can be fully controlled by pesticides. Foliar insecticides should be applied during major plant flushes as this psyllid's development and reproduction need young leaves (Browning, et al., 2006). Insecticides recommended for control of this psyllid are in Table 2. Systemic pesticides such as imidicloprid are recommended for young citrus trees (Browning, et al., 2006). The effectiveness of aldicarb is questionable because it may take up to 30 days for the pesticide to move through the trees and reach the psyllids (Browning, et al., 2006). Chlorpyrifos may increase spider mite populations (Browning, et al., 2006). Fenpropathrin is highly toxic to bees (Browning, et al., 2006).

According to Duncan et al., (2006), at this time there is no soil fumigant recommended for pre-plant nematode control, although 1,3-dichloropropene, and metam sodium are registered for this use. Methyl bromide is also a registered alternative, but it is not economically feasible. Additionally, there are few available pesticides for post-plant treatment. Established nematode populations are difficult to control with pesticides. Aldicarb and fenamiphos are the only post-plant chemical controls recommended for citrus nematodes. Fenamiphos has been found to lose effectiveness after multiple applications. Fenamiphos is only available through permits for use in Florida, and its registration will be cancelled on May 31, 2007. Imidacloprid is also registered to suppress citrus nematodes, but should only be used on trees up to 8 feet tall. Additionally, *Myrothecium verrucari*, a biological nematicide, is registered but has not been reported as a recommended chemical for controlling citrus nematodes.

Beneficial, non-target organisms are also important when considering alternative pesticides. Formetanate, dicofol, sulfur, and oxamyl are highly toxic to beneficial insects, mites, or honey bees and could be disruptive to IPM programs and pollination.

Non-chemical methods used to suppress spider mites in some Florida groves include predacious mites, insects and entomopathogens. Although such biological controls are available, they are not well understood (Childers et al., 2006). Other non-chemical controls include not using trunk wraps, removing infested trees, planting resistant rootstocks and removing tree limbs preferred by mites (Crop Profile for Citrus (Major) Orange/Grapefruit in Florida, 2001.)

BIOLOGICAL CONCLUSIONS

According to the Crop Profile for Citrus in Florida (2001), the loss of aldicarb may result in an estimated 5 to 10 percent citrus production loss in Flordia. Additionally, the loss of aldicarb may increase the need for other pesticides because aldicarb provides a longer period of residual insect control compared to its alternatives. Aldicarb does not appear to be the best available pesticide to control the Asian citrus psyllid compared to the available alternatives. No feasible alternative is available for nematode control in Florida. In Texas, there are several potential alternatives for aldicarb to control mites.

ECONOMIC ANALYSIS

The biological analysis shows that there are several possible alternatives to aldicarb for control of mites in citrus. Estimated costs per acre and acreage treated with possible miticide substitutes for aldicarb are given in table 3. In contrast, a treatment of aldicarb in citrus costs about $70 to $80 per acre in Florida, and about $105 per acre in Texas. When comparing the cost of the miticides in the table to aldicarb, be sure to note that aldicarb also provides nematode control, and that multiple treatments of miticides may be necessary. The chemicals shown in table 3 provide effective control of mites, but good practice requires not treating with the same chemical back to back, to avoid promoting resistance problems with mites. Also, note that these data are based on current practice, where aldicarb is also available to the grower.

Table 3. Current Usage and Cost of Chemicals Identified for Mite Control

	Florida				Texas	
	Oranges		Grapefruit		Grapefruit	
	Acres Treated	Cost ($/Acre)	Acres Treated	Cost ($/Acre)	Acres Treated	Cost ($/Acre)
Abamectin	219,962	33	65,723	43	15,033	48
Dicofol	10,115	26	6,737	24	30,038	22
Fenbutatin Oxide	24,493	41	33,441	44	14,237	46
Fenpropathrin	8,460	20	2,158	16	*	*
Propargite	3,027	25	*	*	11,868	54
Pyridaben	38,972	42	37,873	41	*	*

Source: EPA Proprietary Data
*Insufficient use data for reliable estimates.

Mite damage does reduce the quality of fruit (preventing sale into the fresh market), but almost all of Florida oranges are used for juice. Over the last five years, less than three percent of Florida oranges have been sold into the fresh market (Florida Department of Citrus). Potential quality losses are more important for grapefruit, where about 35 percent of Florida (Florida Department of Citrus) and 60 percent of Texas grapefruit (USDA NASS, 2004) are delivered to the fresh market. Because the miticides in table 3 are expected to provide good control, we do not anticipate yield losses if they are used in place of aldicarb. However, multiple treatments may be required to match the residual control of aldicarb. To know whether the cost of mite

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control would increase would require developing plausible management strategies, and estimating the costs within the context of those strategies.

There are few options for nematode control in citrus, other than aldicarb. Our biological analysis has indicated that fenamiphos is a possible alternative to aldicarb. However, fenamiphos has been cancelled, effective in 2007, so it is not a feasible alternative in the long run. In addition, the benefits of aldicarb for control of mites as a secondary pest will also be lost.

Although greening disease, a bacterial disease vectored by psyllids, is potentially a serious problem in Florida citrus, it is not clear that aldicarb is an effective control, or that any other chemical treatment for psyllids is available, so we do not anticipate major economic impacts if aldicarb were not used.

Our biological analysis suggests that the absence of aldicarb for use on citrus acreage can result in yield losses of 5 to 10 percent. Therefore, the cost to growers will be quite high. A 5 to 10 percent yield loss to the "average" grower in Florida corresponds to a $97 to $193 in lost revenue per acre[1]. For the grapefruit grower, a 5 to 10 percent yield loss corresponds to a loss in revenue of $109 to $218 per acre[2]. If the loss to nematodes increased over time, as nematode populations increase, these losses may get worse. The 2000/2001 – 2004/2005 value of orange production in Florida was about $1.1 billion and the value of grapefruit production was about $209 million. A 10 percent reduction on the 7 percent of acreage treated with aldicarb would result in a loss of approximately $3.9 to $7.8 million annually to Florida orange growers, and $0.7 to $1.5 million to Florida grapefruit growers.

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[1] This result is calculated using the five year average orange yield of 359 boxes per acre and the five year average price of $5.37 per acre. These were calculated using USDA NASS data from the *Citrus Fruits 2005 Summary* and the *Citrus Fruits 2003 Summary*.

[2] For grapefruit the data are also from the *Citrus Fruits 2005 Summary* and the *Citrus Fruits 2003 Summary*. The 2004 – 2005 price and yield are not used in the average, because price is extremely high ($16.26 per box) relative to prior years (the average from 2000/2001 through 2003/2004 is $4.87 per box) and yield is very low (180 boxes per acre) relative to prior years (the average from 2000/2001 through 2003/2004 is 448 boxes per acre). The average grapefruit yield used in these calculations is 448 boxes per acre, and the average grapefruit price is $4.87 per box.

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